A COMPUTATIONAL FLUID DYNAMICS MODEL OF A SOFC

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A three-dimensional model has been developed to simulate the steady state single cell performance of a planar solid oxide fuel cell (SOFC). The governing equations for heat and mass balances were solved numerically with a computational fluid dynamics code (CFD) based on the finite volume method. Numerical results from this simulation show that the concentration of fuel is reduced along the flow direction as the reactant is consumed; leading to a similar distribution for the current density. Temperature variation due to the conjugate heat transfer between fluid and solid also rise with the flow. The results are indicative of significant temperature gradients within the cell, and identify mechanical integrity as a significant issue for SOFCs.

To date, much of the research into the emerging SOFC technology has been concerned with development of the electrochemical and materials issues necessary to produce a working fuel cell. However, as this technology is advancing from the prototype to the manufacture stage, issues affecting the reliability and durability of cells are becoming increasingly important. Several factors are known to introduce mechanical concerns into SOFCs and these are directly related to the operating conditions and design of the cell. In particular, the temperature distributions caused by fluid flow and reactions impinge directly on stresses within ceramic components and these stresses can be significant. For this reason, it is timely to develop models of flow and temperature to help quantify these effects in SOFCs. Furthermore, modelling is an essential stage in advancing design because of its relative inexpense compared with manufacture.

In the current work, a co-flow planar SOFC has been modeled using a CFD code that includes a three-layer cell. Anode, electrolyte and cathode are enclosed by metallic interconnects which contain pillars functioning as contacts for current collectors above and below. The electrical performance of the SOFC is measured by its current and voltage, and these are reported in this paper. The aim of this work is a parametric study due to changes of inlet gas temperatures and operating temperature levels to observe their effects on cell performance. The presented hydrogen concentration, current density, Nernst potential and cell voltage are self consistent and as anticipated and all are observed to decline as the fuel moves further into the cell.

Figure 1. Geometry of the cell

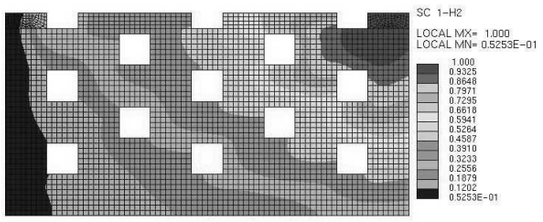

Figure 2. H_2 concentration contour plot in the flow channel

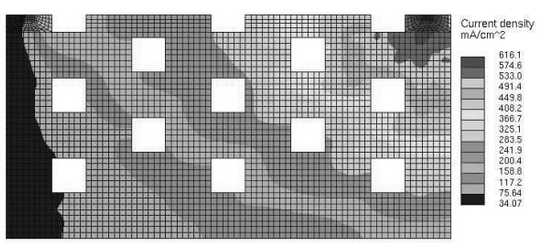

Figure 3. Current density distribution plot at the anode

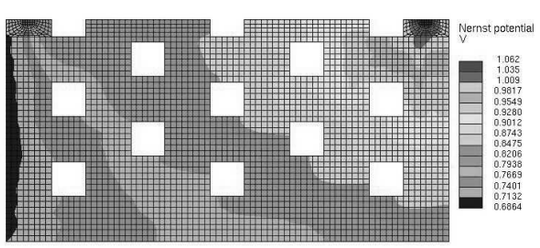

Figure 4. Nernst potential profile at the anode

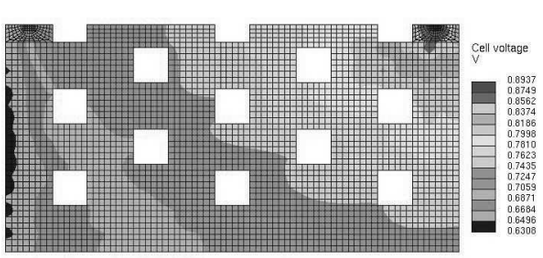

Figure 5. Cell voltage profile at the anode